IFF-RCA-09-10-08

Is the 2008 NASA/ESA double Einstein ring actually a ringhole signature?

Pedro F. González-Díaz[1, *]

[1] *Colina de los Chopos, Instituto de Física Fundamental, Consejo Superior de Investigaciones Científicas, Serrano 121, 28006 Madrid, Spain*

It is argued that whereas the Shatskiy single rings produced by the gravitational inner field of a spherically symmetric wormhole could not be used to identify its presence in the universe or the contents of a parallel universe because such rings may be confused with the most familiar Einstein rings, the image which the inner gravitational field of a ringhole with toroidal symmetry would allow us to detect from a single luminous source situated behind the ringhole in our universe or in a parallel universe is that of two concentric bright rings, and this is a signature that cannot be attributed to any other single astronomical object in whichever universe it may be placed. At the beginning of 2008 the NASA/ESA Hubble Space Telescope revealed a never-before-seen phenomenon in space: a pair of glowing rings, one nestled inside the other like a bull's-eye pattern. It is our alternate proposal in this paper to attribute such a discovery to the first astronomical ringhole found in the universe, rather than to the highly unlikely double lensing effect produced by the required ultra precise alignment of three galaxies along the line of sight. After all, a ringhole is a perfectly valid solution to the Einstein equations and the stuff which makes it possible is becoming more and more familiar in cosmology.

PACS numbers: 95,30.sf, 04.40.-b

Among the reactions that greeted the Shatskiy proposal [1] that wormholes, which are usually disguised as black holes, can be made observable and recognizable in terms of bright, glowing rings originating from the necessary flaring out which is produced by the presence of the so called phantom matter around their throat, there was one typical outburst which was remarked by the sentence: "It is an interesting thing to think about, maybe after a few beers." [2]. For sure, even more offensive statements were expressed against the existence of black holes some 30 years ago. As we all now know black holes have become commonplace in astronomy and fundamental physics. Similarly, wormholes are expected by an increasing number of scientists to also become commonplace in physics not too far in the future. There were more serious criticisms to the Shatskiy work though. In my opinion, the really most devastating argument against the wormhole distinguishable character of the Shatskiy rings is that, even if exotic matter does exist, other many objects are able to create a similar light signature [3]. In particular, it is hard to see how these rings could be differentiated from the astronomical blueprint left by negative energy stars and, mainly, from all those massive astronomical objects whose gravitational lensing effects appear as the so called Einstein rings.

The actual problem is with the symmetry of the throat. Wormholes are characterized by a spherically symmetric throat and, therefore, the diverging lensing effect would necessarily manifest by the observer interpretation of the luminous source as a single ring source, as indicated by Shatskiy. This pattern could well be misinterpreted as being originated from a star or other massive astronomical object, instead of a wormhole, with a radius quite smaller than that for that wormhole throat radius. An inner tunneling symmetry which would give rise to an inexorably distinguishable lensing pattern is that of a ringhole [4], that is, a space-time tunnel whose throat has the toroidal symmetry (see Fig. 1 (a)). Using the set of geometrical parameters specified in this upper part of Fig. (1) we can derive the metric for a ringhole to be [4]

$$ds^2 = -C_2 r^2 dt^2 + b^2\left[1+\frac{C_1 a^2\sin^2\varphi_2}{r^6\left(1-\frac{A^2}{r^4}\right)}\right]d\varphi_2^2 + m^2 d\varphi_1^2 \quad (1)$$

where

$$A = a^2 - b^2,\ \ m = a - b\cos\varphi_2,\ \ r = \sqrt{a^2+b^2-2ab\cos\varphi_2}, \quad (2)$$

with C_1 and C_2 arbitrary integration constants, and a and b the radius of the circumference generated by the circular axis of the torus and that of a torus section, respectively, with $a > b$. Metric (1) is defined for $0 \leq t \leq \infty$, $a-b \leq r \leq a+b$ and the angles (see Fig. 1 (a)) $0 \leq \varphi_1, \varphi_2 \leq 2\pi$.

In order to check the properties of a ringhole as a lens, we now write the static spacetime metric of a single, traversible ringhole in the form

$$ds^2 = -dt^2 + \left(\frac{n_\ell}{r_\ell}\right)^2 d\ell^2 + m_\ell^2 d\varphi_1^2 + \left(\ell^2+b_0^2\right)d\varphi_2^2, \quad (3)$$

where $-\infty < t < +\infty$, with $-\infty < \ell < +\infty$ the proper radial distance of each transversal section of the torus, and

$$m_\ell = a - \left(\ell^2+b_0^2\right)^{1/2}\cos\varphi_2,\ \ n_\ell = \left(\ell^2+b_0^2\right)^{1/2} - a\cos\varphi_2, \quad (4)$$

$$r_\ell = \sqrt{a^2 + ell^2 + b_0^2 - 2\left(\ell^2+b_0^2\right)^{1/2} a\cos\varphi_2}, \quad (5)$$

*Electronic address: p.gonzalezdiaz@imaff.cfmac.csic.es

in which b_0 is the throat radius. As ℓ increases from $-\infty$ to 0, b decreases monotonously from $+\infty$ to its minimum value b_0 at the throat radius, and as ℓ increases onward to $+\infty$, b increases monotonously to $+\infty$ again. Now, for metric (3) to describe a ringhole we must embed it in a three-dimensional Euclidean space at fixed time t [4] whose metric can be written as

$$ds^2 = dz^2 + dr^2 + r^2 d\phi^2 = \left[1 + \left(\frac{dz}{dr}\right)^2\right] dr^2 + r^2 d\phi^2, \tag{6}$$

with $dz/dr = \left(b^2/b_0^2 - 1\right)^{-1/2}$. The requirement that ringholes be connectible to asymptotically flat spacetime entails at the throat that the embedding surface flares outward for $2\pi - \varphi_2^c > \varphi_2 > \varphi_2^c$, and flares inward for $-\varphi_2^c < \varphi_2 < \varphi_2^c$, with $\varphi_2^c = \arccos(b/a)$, which respectively satisfy the condition $d^2r/dz^2 > 0$ and $d^2r/dz^2 < 0$ at or near the throat.

It follows [4] that one would expect lensing effects to occur at or near the ringhole throat, that is to say, the mouths would act like a diverging lens for world lines along $2\pi - \varphi_2^c > \varphi_2 > \varphi_2^c$, and like a converging lens for world lines along $-\varphi_2^c < \varphi_2 < \varphi_2^c$. No lensing actions would therefore take place at $\varphi_2 = \varphi_2^c$ and $\varphi_2 = 2\pi - \varphi_2^c$.

In fact, in the case of ringholes, instead of producing just a single flaring outward for light rays passing through the wormhole throat, this multiply connected topology, in addition to that flaring outward (diverging) effect, also produces a flaring inward (converging) effect [4] on the light rays that pass through its throat, in such a way that an observer on Earth would interpret light passing through the ringhole throat from a single luminous source as coming from two bright, glowing concentric rings, which forms up the distinctive peculiar pattern from ringholes (See Fig. 1 (b)). That pattern cannot be generated by any other possible disturbing astronomical object other than a very implausible set of three luminous massive objects (let us say galaxies) which must be so perfectly aligned along the sigh line that its occurrence becomes extremely unlikely.

It is readily inferred from Fig. 1 (b) that, for a reasonably large ringhole sufficiently far from the luminous source, the inner bright ring would correspond to the flaring inward (converging) surfaces. If we keep the ringhole size invariant and the distance between the ringhole and the luminous source is decreased drastically, then the inner bright ring would turn to be produced by the flaring outward (diverging) surface.

Such a ringhole signature may have been already observed though it has been so far attributed to the combined effect of two Einstein rings originated from the above-considered to be extremely unlikely superprecise alignment of three galaxies. In fact, at the beginning of 2008 The NASA/ESA Hubble Space Telescope revealed [5] a never-before-seen phenomenon in space: a pair of glowing rings, one nestled inside the other like a bull's-eye pattern. This double-ring pattern was interpreted as a double Einstein ring being caused by the complex

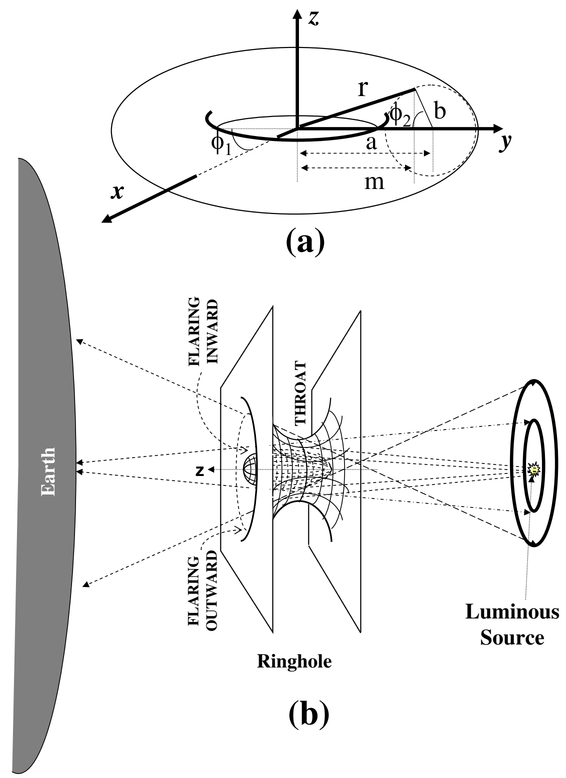

FIG. 1: Gravitational lensing effect produced by a ringhole from a single luminous source. (a) Parameters defining the toroidal ringhole throat in terms of which metric (1) is defined. (b) Rays passing near the outer and inner surfaces respectively flare outward and inward, leading to a image from a luminous point placed behind the ringhole which is made of two concentric bright rings. The relative mutual positions of these rings would depend on the distance between the ringhole and the luminous source. If that distance is small enough then the larger outer ring comes from the flaring inward surface, and conversely, if the distance source-ringhole is increased then the outer ring comes from the outward surface, the larger that distance the greater the difference between the two bright rings.

bending of light from two distant galaxies strung directly behind a foreground massive galaxy, like three beads on a string along the line of sight, simply because at the time there were no other available interpretations for what was being observed. Being more than just a novelty, this very rare phenomenon found with the Hubble Space Telescope could, moreover, eventually offer insight into dark matter, dark energy, the nature of distant galaxies, and even the curvature of the Universe.

As previously stated, for that interpretation to be feasible, the massive foreground galaxy had to be almost perfectly aligned in the sky with two background galaxies at different distances to justify the finding. The foreground galaxy is 3 billion light-years away. Now, in order to justify the ratio between the two ring radii, the inner ring and outer ring would be comprised of multiple images of two galaxies at a distance of some 6 billion and

approximately 11 billion light-years.

However, the odds of observing the required extremely precise alignment of the three galaxies are so small (an estimated 1 in 10,000) that even some of the discoverers of that astronomical phenomena said that they had 'hit the jackpot' with the discovery. At the time, the authors of Ref. [5] had no alternative other than accepting that quite improbable interpretation of the result. Nevertheless, having we uncovered in this letter that such concentric rings may well be also interpreted as the blueprint of the presence of a ringhole in the direction in space where the double bright ring system was discovered, we adopt the latter interpretation in terms of a ringhole as the most probable explanation for that phenomenon, taking now the luminous sources at redshifts corresponding to 3 and 6 billion light-years as measuring the positions of the two ringhole mouths on the sky, and their respective luminosities as stemming from the respective light deflections along the angle φ_2 caused by the combined effect of the size of the throat radius and the relative distance between the two mouths.

In this case, besides valuable information on dark matter, dark energy and universe curvature, what could eventually be most astonishing in its implications would be an unprecedented insight into the content of other universes linked to ours by means of ringholes. Not with standing, in spite of the apparent evidence in its favor, I only present here the ringhole interpretation of the results of Ref. [5] as just a possible alternate implication, probably the most likely one now at our disposal. After all, a ringhole is a perfectly valid solution to the Einstein equations for a exotic stuff - possibly phantom energy- which is becoming more and more familiar in the full context of current cosmology. The potentially attainable insight from such an interpretation is twofold. On the one hand, we would get a direct evidence for the existence of ringholes and, by the way, possibly of wormholes, and on the other hand, we could have found the door to a parallel universe, and hence got a first direct evidence for the existence of the multiverse scenario.

There is an observation which may in principle distinguish a static ringhole staying within our own universe and having its two mouths at rest with respect to each another, from a ringhole that connect our universe to a parallel universe or, in general, to other universe of a multiverse scenario. In the latter case since there is no common space-time for the two universes (parallel or not), the two mouths should necessarily be in perpetual quasi periodic relative random motion with completely unspecified speed. This would make the time and space for the two universes at all independent because the relative motion of the two mouths converts the ringhole in a time machine that contains completely arbitrary closed timelike curves. In the case of the inner static ringhole, if the luminous source is kept motionless and the ringhole does not behave like a time machine, the two concentric rings would be well resolved and defined on the pattern. However, if the positions of the two mouths continuously vary relative to each other in a random though quasi periodic way then the width of each of the two concentric rings would be stretched out and their resolution spoiled and clearly blurred due to the continuous and completely arbitrary changes of distance between the two mouths, thus leading to a glowing background around the rings, showing just a maximum of intensity at the average relative position of the mouths, provided the relative motion keep a sufficiently high degree of periodicity. In the latter case, the metric of the ringhole would change to be given by a line element that describes arbitrary time travel induced by a nearly periodic relative motion between the two mouths. Using arguments similar to those used in Ref. [4] we finally get

$$ds^2 = -\left[1 + \bar{g}F(\ell)\sin\varphi_1\right]^2 dt^2 + d\ell^2 + m_\ell^2 d\varphi_1^2 + b^2 d\varphi_2^2, \tag{7}$$

where $\bar{g} = \bar{\gamma}^2 \frac{d\bar{v}}{dt}$ is the average acceleration of the moving mouth, with $\bar{v}$ the corresponding average velocity, and $\bar{\gamma} = 1/\sqrt{1-\bar{v}^2}$ is the average on the fuzzy relativistic factor; finally $F(\ell)$ is a form factor that vanishes in the half of the ringhole which is assumed to be kept motionless, and rises up on average from 0 to 1 as one moves along the direction of the moving mouth. We must finally point out that any ringhole which is a time machine even within our universe will also show an defocused two-rings pattern though not so blurred perhaps as that corresponding to an inter-universe ringhole. The phenomenon of defocusing would also take place in the single ring pattern produced by a wormhole if this behaves like a time machine or inter-connects two distinct universes.

The image of the system SDSSJ0946+1006, as photographed by Hubble Space Telescope's Advanced Camera for Surveys [5], shows a focusing of the two rings that could be compatible with the two types of ringholes that we have just considered, though it seems to be resolved enough as for attributing it to the gravitational effect from a static ringhole staying in our universe. New findings would become very useful in order to distinguish better between these two kinds of ringholes.

We finally briefly discuss the odds of finding a macroscopic ringhole which is kept stable. It was first argued [6] that only quantum wormholes, and hence quantum ringholes, with nearly the Planck size can be stable, with larger tunnelings being violently destabilized by quantum effects produced by catastrophic particle creation taking place near the chronology horizons. Actually, Hawking even advanced his chronology protection conjecture [7] for wormholes which can also be applied to ringholes, preventing the appearance of closed timelike curves, so making the universe safe for historians and free of the occurrence of the kind of phenomena dealt with in this letter. Thus, neither wormholes nor ringholes could exist due to these quantum fluctuation instabilities.

However, besides some counter-examples to the Hawking's conjecture that includes e.g. some compelling argument by Li and Gott [8], it has been shown [9] that both

macroscopic wormholes and macroscopic ringholes can be stabilized after the coincidence time by the accelerating expansion of the universe which induces their throat to quickly growing comovingly to the super-luminal universal expansion. On the other hand, similarly to as it happens with wormholes [10], accretion of phantom energy onto the ringholes should also induce in them a ultra rapid swelling up that would circumvent the kind of quantum effects considered by Hawking so that, such as it also happens with their above-mentioned size increasing which is comoving to the universal expansion, the destabilizing quantum effects here cannot act in time to destroy the tunnel during the current speeding-up of the universe. Therefore, the odds for ringholes to exist and gravitationally act on the light coming from luminous sources the way we showed before appear to be good enough in the the context of our accelerating universe as for allowing the kind of interpretation considered in this letter.

Acknowledgments

This work was supported by MICINN under research project no. FIS2008-06332. The author benefited from discussions with C. Sigüenza of the *Estación Ecológica de Biocosmología* of Medellín, Spain.

[1] A. Shatskiy, astro-ph/0712.2572 .
[2] D. Holz, as cited in A. Swarup, *Finding the door to a parallel universe*, New Scientist, 2 February, 2008, page 13.
[3] A. Einstein, Science 84, 506 (1936) .
[4] P.F. González-Díaz, Phys. Rev. D54, 6122 (1996).
[5] R. Gavazzi, T. Treu, L.V. E. Koopmans, A.S. Bolton, L.A. Moustakas, S. Burles and P.J. Marshall, *The Sloan Lens ACS Survey. VI: Discovery and analysis of a double Einstein ring*, astro-ph/0801.1555 .
[6] P.F. González-Díaz, Phys. Rev. D58, 124011 (1998) .
[7] S.W. Hawking, Phys. Rev. D46, 603 (1992) .
[8] Li-Xin-Li and J. R. Gott, Phys. Rev. Lett. 80, 2980 (1998) .
[9] P.F. González-Díaz, Phys. Rev. D68, 084016 (2003) .
[10] P.F. González-Díaz, Phys. Rev. Lett. 93, 071301 (2004) .